Settlement Risk in Large-Value Payments Systems

By Pu Shen

Over the past two decades, the phenomenal growth of financial market and trading activities worldwide has led to tremendous growth in large-value payments systems. Large-value payments systems are the electronic systems banks use to transfer large payments among themselves.[1] Payment orders processed in such systems in the United States, for example, are typically well above $1 million.

The tremendous growth of payments system use throughout the world has increased both the possibility of settlement failures and the potential impact of such failures. Two decades ago, the risks were relatively low. For example, the daily payment flow of foreign exchange transactions was roughly the same magnitude as the capital stock of a large U.S. bank. In 1996, however, the average daily turnover exceeded the combined capital of the top 100 U.S. banks. Regulators are especially concerned that payments systems might turn a local financial crisis into a global systemic crisis.

This article examines settlement risk in large-value payments systems and discusses some of the measures available to manage such risk. The first section describes the features of the two primary types of large-value payments systems. The second section discusses the three different forms of settlement risk—credit risk, unwinding risk, and liquidity risk. The third section examines some of the measures that have been adopted to manage settlement risk, pointing out the merits of these measures as well as tradeoffs between their costs and their ability to reduce risk.

I. WHAT ARE LARGE-VALUE PAYMENTS SYSTEMS?

Payments systems are the infrastructure of the modern business world. All business and financial transactions involve monetary payments.[2] A transaction which is not paid in cash (currency bills and coins) has to be paid by transferring funds from the buyer's bank account to the seller's bank account. If both the buyer and seller have accounts with the same bank, this can be done easily through the bank: the bank simply debits the buyer's account and credits the seller's account by the same amount. But if the buyer and seller use different banks, which is usually the case, the funds transfer, that is, settlement, has to be accomplished by using a payments system.

A payments system works like a bank's bank. All member banks of a payments system hold accounts with deposits that can be used as clearing

Pu Shen is an economist at the Federal Reserve Bank of Kansas City.

balances with the system. Payments among member banks are settled by simultaneously debiting and crediting the respective accounts of paying and receiving banks. For example, suppose a California insurance company, Pacific Insurance Group, buys $20 million in Treasury bonds from a Wall Street security firm, Atlantic Securities Company. Because Pacific and Atlantic use different banks, Pacific's payment to Atlantic must be accomplished through a payments system by using banks who are members of the same system. Pacific pays its bank $20 million, which in turn pays Atlantic's bank $20 million through the payments system, just as a buyer pays a seller when they have a common bank. Atlantic's bank then pays Atlantic $20 million.

There are two types of large-value payments systems in operation. One is a real time gross settlement, or RTGS, system. The other is a periodic multilateral netting system. In the United States, the two major large-value payments systems are Fedwire, an RTGS system, and CHIPS, a netting system.

RTGS systems

The single most important feature of an RTGS system is that it provides instant settlement with finality as soon as a payment instruction arrives, provided that sufficient funds are available in the account of the sending bank. Settlement refers to the actual transfer of funds from a sending bank to a receiving bank. Finality means that the settlement is unconditional and irrevocable. In an RTGS system, real time means that payment instructions are executed continuously, at the instant they enter the system, while gross settlement means that for each payment instruction, the total gross amount of funds is transferred.

In the United States, Fedwire is an RTGS system with nearly 7,000 active member banks, all of which hold reserve accounts at Federal Reserve Banks. Operated by the Federal Reserve System, Fedwire currently processes nearly $1 trillion in payments on an average day, or roughly ten times as much as 20 years ago.[3] Fedwire is used mainly for interbank payments, many of which are related to federal funds transactions or payments for the purchases of government securities.

A typical Fedwire transaction takes only a few seconds. Suppose that in the previous example the banks of both Pacific Insurance and Atlantic Securities belong to Fedwire. Once Fedwire receives the payment instruction of $20 million from Pacific's bank, the bank's account at the Federal Reserve will be debited $20 million while the account of Atlantic's bank at the Federal Reserve will be credited $20 million. Once this funds transfer is completed, the payment is said to be settled. Fedwire sends an electronic message to Atlantic's bank to confirm the settlement.

Outside the United States, there are currently only a few RTGS systems, two of which are the Swiss Interbank Clearing (SIC) system and the Clearing House Automated Payment System (CHAPS) in the United Kingdom. SIC has been in full operation for more than ten years, while CHAPS was just recently converted to an RTGS system. However, many more RTGS systems are planned to be introduced in European Union countries in the near future. Some Asian countries are considering RTGS systems as well.

Netting systems

In contrast to RTGS systems, settlements in netting systems do not occur immediately when payment instructions are sent. Typically, when a netting system receives a payment instruction, the system immediately informs the receiver if the instruction meets certain criteria. But the actual settlements are not accomplished until the end of the day. After the cutoff time for sending payment messages, the system calculates the net payments, or settlement obligations, for each participant and informs the participants of their obligations. The funds transfers are then made and settlements are achieved.

Table 1 uses a three-bank example to show how a netting system processes payments for its member banks. The column under each bank shows payment instructions received by the bank during the day from each bank across the row. For example, the first column shows that Ash Bank has received payment instructions during the day from Birch Bank for $10 million and from Cedar Bank for $20 million. The total credit row shows the sum of the payments each bank in the column received during the day. The total debit column shows the sum of the payments each bank in the row instructed the system to pay during the day. These numbers are copied to the total debit row. After the cutoff time, the difference between the total credit and total debit is calculated for each bank. This difference is called the net position. If the net position is positive, it represents the amount owed to the bank at the settlement time. A negative net position, shown in parentheses in the table, represents the amount of the payment due from the bank.[4] The net position of each column bank is shown in the last row of the table.

The table illustrates the primary difference between RTGS and netting systems. In an RTGS system, each payment in the first three rows would be settled as soon as the payment instruction is sent. In a netting system, however, the system informs the receivers and keeps track of all payment instructions during the day, but the actual funds transfers are only made at end of the day. In the example shown in the table, Cedar Bank pays the payment system $10 million at the end of day, and the system then transfers $5 million to the accounts of both Ash and Birch.

The most important implication of the difference between RTGS and netting systems is that netting systems only have *conditional* finality. In a well-organized netting system, payment instructions sent to the systems are not allowed to be revoked once they have been accepted by the system and released to the receiving banks. In this sense, netting systems have finality. But this finality is only conditional, depending on the absence of a settlement failure. A settlement failure occurs if one or more members of the netting system default on their settlement obligations and the system does not have sufficient funds to cover the shortfalls. If a settlement failure occurs, a netting system has to allow its participants to revoke all or part of the payment instructions sent during the day. Thus, the finality in a netting system is conditioned on the success of settlement at the end of the day.

Another distinguishing feature of netting systems is that they need not be run by a settlement agent. Functionally, a netting system can be separated into two parts: a clearinghouse and a settlement agent. The clearinghouse records all payment instructions, checks whether the instructions satisfy certain specific rules and conditions, and if so, releases them to receiving participants. At the end of the day, the clearinghouse calculates the net settlement obligations for each member and informs them of their obligations. The settlement agent then accomplishes the actual funds transfers. Consequently, the function of the clearinghouse can be operated by any organization, bank or nonbank, private or public. On the other hand, a settlement agent is a bank's bank, which makes a country's central bank the natural choice for this role.[5] In contrast to a netting system, an RTGS system is usually operated by its settlement agent because the system requires continuous, or real time, settling. Thus, in an RTGS system, it is not practical to separate the operation of the system from its settlement agent.

Table 1

A NETTING PAYMENT SYSTEM

(amounts in millions of dollars)

Paying bank	Receiving bank			
	ASH	BIRCH	CEDAR	Total debit
ASH		15	10	25
BIRCH	10			10
CEDAR	20			20
Total credit	30	15	10	
Total debit	25	10	20	
Net payment bank receives (owes) at settlement	5	5	(10)	

In the United States, the biggest payments system in terms of processing value is the Clearing House Interbank Payments System (CHIPS). CHIPS is a netting system with roughly 100 U.S. banks and U.S. branches of foreign-based banks from about 30 countries. CHIPS is privately owned and managed by the member banks of the New York Clearing House Association. All CHIPS members are directly linked through a computer network. Currently, CHIPS processes more than $1.2 trillion in payment orders on an average day, which is almost 20 times as much as two decades ago. The system is designed to facilitate payments among its member banks, especially dollar payments generated by foreign exchange transactions. CHIPS has a settlement account at the Federal Reserve Bank of New York and uses the Federal Reserve System as its settlement agent.

In most European countries, netting systems have historically been the predominant choice for large-value payments. Many central banks in these countries, however, are now planning either to introduce RTGS systems or convert some existing netting systems to RTGS systems. The main reason behind this strategy is the concern for settlement risk, especially for unwinding risk, in netting systems.

II. WHAT IS SETTLEMENT RISK?

Settlement risk refers to the risk that financial losses may occur when payments systems are used for settlement. Settlement risk appears in different forms to different payment arrangements or payments systems. There are mainly three forms of settlement risk: credit risk, unwinding risk, and liquidity risk.

Credit risk

In general, credit risk is the risk that a payer might lose all or part of its payment due to the counterparty's failure to deliver its promised payment. All business transactions involve two sides. One side of the transaction generally makes a monetary payment, such as dollars. The other side pays goods or services in a business transaction, stocks or bonds in a security transaction, or currencies in a foreign exchange transaction. Credit risk arises when the two sides of a transaction do not pay simultaneously.

In payments systems, it is useful to separate credit risk into two types: first payer risk and receiver risk. *First payer risk* is the risk that the party who pays first might not receive the corresponding payment from the counterparty. A first payer is exposed to the credit risk until the payment due from the counterparty is received with finality. First payer risk is not unique to payments systems; it exists in any transactions when there is a first payer. *Receiver risk* arises when a receiver assumes that a received payment is final before it actually is and therefore pays its side of the obligation with finality. In this way, the receiver actually becomes a first payer and assumes first payer risk. Receiver risk is more common in payments systems than in other types of business. For example, in a netting system, an institution may assume the payments it receives are final. But in actuality, the institution is extending credit to the sender and the payment is final only when the settlements occur at the end of the day.

Receiver risk also exists in an RTGS system because institutions can be indirect users. An indirect user is not a member of the payments system, but uses a bank that is a member. For example, both Pacific Insurance Group and Atlantic Security Company in the transaction discussed earlier are indirect users. An indirect user is exposed to receiver risk due to the time lag between the time its bank receives a payment and the time the bank notifies its customer, the final receiver. For example, it is currently common practice for a bank to notify its customers of funds transfers after a one-day delay. Since payments systems have worked well historically, many indirect users simply assume a payment instruction is settled the day it arrives. If such an assumption is mistaken, however, the indirect user will not find out its error until a full day later. In the earlier example, Atlantic might deliver the Treasury bond to Pacific with finality but learn the next day that the expected wire transfer from Pacific did not arrive the day before. Thus, current business practice exposes indirect users of an RTGS system to receiver risk.

While credit risk is a common concern in most business transactions, it is easy to overlook such risk in payments systems. It may be overlooked because such extension of credit is not intentional but arises from routine payment operations. Also, the extension of credit is perceived by many as for a very short term, less than a day. This perception can be mistaken, however, since the actual exposure is often longer than a day when accounting for the risks to indirect users. Because the sizes of such exposure tend to be large, credit risk in payments systems is both real and significant.

Credit risk is especially acute in foreign exchange transactions since payments systems in different countries need to be involved. For example, suppose that Bank of Potomac sells 180 million English pounds to the Bank of Thames for 100 million U.S. dollars. Because payments systems currently process only the home country's currency, the dollar side of the transaction has to be settled in the United States and the pound side in Britain, through foreign branch offices of the two banks.[6] Specifically, Potomac's branch office in England transfers 180 million pounds to Thames through CHAPS, the British large-value payments system, while Thames's branch office in the United States transfers $100 million to Potomac through CHIPS. Since different countries are often in different time zones, the time lag between the settlement of the two sides of currency payments is likely to be substantial. The difference between London time and New York time, for example, is five hours, so when CHIPS settles, CHAPS has been closed for hours. In fact, a recent survey found that in many currency transactions, the risk exposure could last more than a couple of days.[7] Further, since the sizes of the transactions tend to be large, the potential losses can be severe.

The credit risk in foreign exchange transactions is illustrated by the failure of Bankhaus Herstatt in 1974. Since then, this risk has often been referred to as "Herstatt risk." Herstatt was a small German bank that was involved in many foreign exchange transactions when it failed. The closure of the bank was announced on June 24 at 3:30 p.m. German time, or 10:30 a.m. New York time.[8] The cutoff time for the German payments system was two hours earlier, at 1:30 p.m. local time. Thus, banks that had sold deutsche marks to Herstatt for U.S. dollars for settlement on June 24 had already irrevocably paid Herstatt the marks, expecting to receive the U.S. dollar payments from Herstatt through CHIPS later in the day. But because Herstatt was closed before the dollar side of the transaction was settled on CHIPS, Herstatt's counterparties—the first payers—did not receive the dollar payments, and therefore faced the prospect of losing the full value of their mark payments.[9]

Although credit risk is present in both RTGS and netting systems, in general, it is smaller in netting systems.[10] The difference depends largely on the amount of "cross traffic" a user has with other members of the netting system. High cross traffic means the netted amount of payment due or owed would be relatively small, resulting in relatively little credit risk exposure. On the other hand, a bank with little cross traffic would not benefit much from netting and thus would be exposed to relatively more credit risk. Using the example in Table 1, the exposures of Ash, Birch, and Cedar are $5 million, $5 million, and $10 million, respectively. If instead they had used an RTGS system, their credit risk could have reached $25 million, $10 million, and $20 million, as shown in the total debit column.

Unwinding risk

Unwinding risk arises because the payment instructions released to receivers may ultimately be revoked, or unwound. Unwinding occurs when there is a settlement failure in a netting system and the payment instructions accumulated during the day are allowed to be revoked. Unwinding risk is only a concern in netting systems, where it is a major risk for both individual users and regulators.

Unwinding can be costly to an affected institution in three ways. First, a user of a netting system may have paid some of its obligations with finality through other systems. If the user's counterparties' payments are unwound, the user becomes a first payer in such transactions and is exposed to first payer risk at least overnight. Second, many of the transactions unwound might have to be renegotiated, which means the institution could lose all gains from these transactions for that day. And third, there are likely to be indirect costs to affected parties. For example, unwinding in one payments system may make it difficult for an institution to fulfill its obligations in other settlements systems, which could require extensive resources to mitigate. Suppose, for example, in a foreign exchange transaction between Japanese yen and U.S. dollars, an unwinding in a yen payments system causes nondelivery of the dollars. The nondelivery may cause the bank expecting the dollar payment difficulty in fulfilling its dollar payment obligations.

In contrast to credit risk, unwinding risk is hard to measure and even harder to manage without collective arrangements. Managing credit risk requires an individual user to know the creditworthiness only of its counterparties. Managing unwinding risk, however, requires an individual user to know the creditworthiness of all members of the same netting system because unwinding could be caused by any member's default on its settlement obligations.

Table 2 shows why unwinding risk can be hard to manage. The structure of the table is similar to Table 1. A row of funds available for clearing purposes for each bank is added. Assume these banks use a netting system that only settles at the end of the day. The top half of the table shows that at the end of the day all banks except Cedar Bank are able to fulfill their settlement obligations. Cedar cannot because it has a net debit payment of $10 million due but has only $2 million in funds available. If the payments system cannot come up with the necessary funds to cover the shortfall, it has to let Cedar unwind. But Cedar's unwinding creates a problem for Ash Bank. The bottom half of the table shows the settlement obligation to each remaining bank after Cedar's payment instructions are unwound. Now Ash has a $5 million payment due with only $2 million in funds available. Thus, Ash cannot fulfill its settlement obligations, leading to a total unwinding in the system.

This example highlights the fact that in a netting system, unwinding risk exposes every user to every other user's risk. In the example, Birch Bank has no direct business dealings with Cedar; nevertheless, it is affected by Cedar's inability to pay its settlement obligations through the resulting chain reaction. Such broad exposure is the fundamental difference between unwinding risk and credit risk.

Unwinding risk is also a systemic risk because, when it occurs, it tends to affect many institutions. When there is a settlement failure, a netting system usually allows affected participants to withdraw their payment instructions sent during the day.[11] But these withdrawals will further affect more participants, who in turn are allowed to revoke their payment instructions. This chain reaction can potentially continue, resulting in an unpredictable but perhaps wide ranging unwinding. To alleviate the uncertainty, some netting systems simply unwind the entire day's transactions if a settlement failure occurs. Either total or partial unwinding is likely to affect many participants and cause large-scale disruption to payment flows as well as to the operation and stability of financial markets. To understand the magnitude of the cost of unwinding, imagine what would happen if, for example, CHIPS were to unwind. Although unwinding has never happened on CHIPS, more than 200,000 transactions with total value over $1.2 trillion would be reversed on a typical day. Unwinding on this scale could shake the confidence of business and investors in the stability of the entire payments system structure, thereby turning a local individual crisis into a widespread systemic crisis.[12]

Liquidity risk

Liquidity risk is the risk that payment instructions cannot be executed (in an RTGS system) or settled (in a netting system) due to the lack of liquidity, even though the involved parties are fundamentally sound. A bank could be in solid financial shape, but it may not be able to pay its settlement obligations, say, because of a temporary breakdown in the communications between its branch offices caused by a snow storm. For example, a branch that was supposed to sell a loan portfolio to obtain the settlement funds might not be able to do so. In other lines of business transactions, this temporary liquidity shortfall may not cause significant difficulties. But for a payments system and its participants, immediate liquidity at settlement time is crucial. For this reason, liquidity risk is a special concern to payments systems.

While liquidity risk exists in all payments systems, it is more acute in RTGS systems

Table 2

UNWINDING AND CHAIN REACTIONS IN A NETTING SYSTEM

(amounts in millions of dollars)

Paying bank	Receiving bank			
	ASH	BIRCH	CEDAR	Total debit
ASH		15	10	25
BIRCH	10			10
CEDAR	20			20
Total credit	30	15	10	
Total debit	25	10	20	
Net payment bank receives (owes) at settlement	5	5	(10)	
Funds available for clearing purposes	2	2	2	

Paying bank	Receiving bank		
	ASH	BIRCH	Total debit
ASH		15	15
BIRCH	10		10
Total credit	10	15	
Total debit	15	10	
Net payment bank receives (owes) at settlement	(5)	5	
Funds available for clearing purposes	2	2	

because gross settlement systems need much more funds—liquidity—to settle. For example, in Table 1, as long as Cedar Bank has $10 million in funds available, all four transactions can be settled in the netting system. But if a gross settlement system is used instead, each bank needs as much liquidity as the gross amount of payment to settle. Ash needs $25 million in liquidity, Birch needs $10 million, and Cedar needs $20 million. Gridlock will occur if all of them lack sufficient liquidity.[13]

Liquidity risk can be reduced, or even eliminated, if all members of a payments system hold ample amounts of liquidity, such as cash or reserve balances that can be used for clearing purposes. But liquidity is costly to its holders; funds held as cash or reserve balances do not earn interest income. Thus, there is a tradeoff between minimizing liquidity risk and minimizing liquidity cost. As a result, from a bank's perspective, it is usually too costly to totally eliminate liquidity risk.[14]

In an RTGS system, liquidity risk highlights the fact that every participant is exposed to every other participant's risk. Liquidity risk is a systemic risk since one participant's liquidity shortfall can lead to liquidity shortfalls for its counterparties who have counted on the incoming payments as their clearing liquidity. Such chain reactions can lead to a systemic liquidity shortfall. Unlike in a netting system, where liquidity is only an issue at end of the day, in an RTGS system, a liquidity shortage at any time would slow down the system's processing or, in the worst case, bring the entire system to a halt—failure.[15] In an RTGS system, any time is settlement time.

The experiences of the Swiss Interbank Clearing system highlight the importance of liquidity in an RTGS system. Member banks of the SIC system need sizable clearing balances to process payments because the system does not provide intraday liquidity. If a sending bank does not have a large enough clearing balance to fulfill its payments, the payment instructions will be queued until the funds are available.[16] Obviously, incoming payments in such a system are an important source of liquidity. To facilitate such liquidity in the system, SIC uses a price mechanism to encourage early payment. As a result, almost half of the daily payment instructions are sent to the system before its opening. Nevertheless, on an average day, at least 45 percent of payments experience some delay in their execution due to the lack of liquidity.[17] In a sense, liquidity shortages keep the SIC system from being a truly *real time* system.

In sum, settlement risk takes the forms of credit risk, unwinding risk, and liquidity risk (Table 3). Credit risk is a bilateral risk that is present in all payments systems, although it is usually smaller in netting systems. In fact, credit risk is ultimately the fundamental source of settlement risk because, without it, there would be no unwinding risk or liquidity risk. For example, in Table 2, if Cedar Bank were fundamentally sound and had only a temporary liquidity shortage, it should easily be able to obtain overnight loans from the other banks. In this case, Cedar would be able to fulfill its settlement obligations (which become zero), which would eliminate the liquidity and unwinding risk.

The severity of unwinding risk and liquidity risk varies with the type of payments system. Unwinding risk is a major source of risk only in netting systems. Although liquidity risk exists in both RTGS and netting systems, it is a major source of risk only in RTGS systems. The unique feature of these two risks in settlement systems is that they expose an institution not only to bilateral risks with its counterparties, but also to risks with every other user of the same payments system.

III. MANAGING SETTLEMENT RISK

Recognizing that both RTGS and netting systems are exposed to settlement risk, regulators and the private sector have been working to reduce the risk. Some of the measures available are relatively straightforward and can be implemented by individual institutions. For example, the length of time between a bank receiving a fund transfer for its customer and notifying the customer could be reduced from one or more days to just minutes, virtually eliminating credit risk to receivers in RTGS systems. Clearly, adopting this measure only requires the cooperation of two participants.[18] Other measures, however, require systemwide efforts. This section will examine and compare some of the risk management measures that require systemwide cooperation.[19]

Credit and liquidity risk in RTGS systems

Settlement risk in RTGS systems consists of credit risk and liquidity risk (Table 3). The primary method to reduce credit risk is delivery-

Table 3
SUMMARY

Payment system	Settlement risk			
	Credit			
	First payer	Receiver	Unwinding	Liquidity
RTGS	Equal to full payment	Equal to full payment (for indirect users only)	None	Major concern
Netting	Less than full payment	Less than full payment	Major concern	Negligible

versus-payment (DVP), while the primary method to reduce liquidity risk is central bank provision of intraday liquidity.

Delivery-versus-payment (DVP). DVP eliminates the credit risk inherent in a transaction because it requires both payments in the transaction to occur with finality at exactly the same time. To incorporate DVP in, say, security transactions, links between a real time monetary clearing system (an RTGS payments system) and a real time security clearing system are established to ensure that a purchasing party will pay at the same time that the counterparty delivers its promised securities. The Federal Reserve has established such a mechanism between Fedwire and the government security clearing system. Similarly, the Swiss Interbank Clearing system has established links with SECOM, an electronic book-entry system for transfer of Swiss securities, to implement a DVP mechanism. Since DVP requires real time payment finality in every transaction, it is only feasible in RTGS payments systems.[20]

In principle, DVP can also be used in foreign exchange transactions, in which case it is called payment-versus-payment (PVP). In reality, however, PVP is extremely difficult to implement for transactions between dollars and other major, non-North American currencies because it would require that all three of the following conditions are satisfied. First, payments systems for both currencies must be RTGS systems. Second, both payments systems must have sizable overlapping operation times. And third, both institutions involved in the transactions must send the payment instructions in the overlapped operation time period. Currently, the main payments system used for settling the dollar side of foreign exchange transactions in the United States is CHIPS, which is a netting system. In addition, Japan and most European countries use netting systems, although many of them are planning to move to RTGS systems in the next few years. Further, the operation hours of Fedwire, the RTGS system in the United States, do not currently overlap with those of most European or Japanese payments systems. The Federal Reserve plans to extend the operation of Fedwire to 18 hours a day by the end of this year; still, it is not clear how many banks will extend their operation hours accordingly.

While DVP eliminates credit risk, its costs are likely to prevent it from being quickly or widely adopted. First, DVP is costly to implement. In addition to the above mentioned requirements, it is also technically demanding on the information and communication capacities of both payments systems and payments system users. For example, to implement DVP for equity security transactions, the payments system must be able to store much more information on the payment instruction. The instruction must not only identify the sender and the receiver(s) of a payment, but also specify the particular security. This additional information would require significant investment in computers and data processing facilities. Further, a user of such a system would have to integrate its departments responsible for making and receiving dollar payments and for transferring equity securities. In many cases, this integration would require new computer and data facility investment, as well as corporate reorganization.

Another potential cost of DVP is that it could exacerbate systemic risk. DVP allows a liquidity shortage in a payments system to tie up the clearing process of its linked systems. For example, in an RTGS payments system, if a large number of payment instructions have to be delayed due to a lack of liquidity, the operation of a linked security clearinghouse will also be slowed, perhaps even halted. Conversely, an interruption in a security clearinghouse could interrupt the operation of a linked RTGS system. Thus, before DVP is implemented, its costs and benefits should be weighed carefully.

Intraday liquidity provided by central banks. As discussed earlier, the major systemic risk concern in an RTGS system is the risk of a liquidity shortage. This risk can be reduced by increasing the liquidity held by its member banks. Banks, however, understandably want to economize on their liquidity holdings because liquidity is costly. Further, because an individual bank does not bear the entire cost of potential chain reactions caused by its liquidity shortage, it will choose a level of liquidity that is less than what is collectively desirable.[21]

Concerned with the systemic impact of a liquidity shortage, central banks often provide intraday liquidity to payments systems. The Federal Reserve, for example, offers both collateralized intraday loans and uncollateralized daylight overdrafts to most member banks of Fedwire. Collateralized loans are usually offered in transactions related to Treasury securities, and the underlying securities are used as collateral. On the other hand, the Federal Reserve also allows a member bank to have a negative balance in its account at the Federal Reserve during the day (daylight overdraft), up to a preestablished limit without providing collateral. In doing so, Fedwire minimizes liquidity risk by effectively guaranteeing that the majority of payment instructions are executed as soon as they arrive to the system.[22]

Providing intraday liquidity, however, can be costly for central banks. For example, in Fedwire, uncollateralized daylight overdrafts are essentially loans to Fedwire members. Thus, the Federal Reserve is exposed to the credit risk that the borrowing banks may default on their loans. In other words, central banks face a tradeoff between reducing liquidity risk in payments systems and increasing credit risk to themselves. The Federal Reserve chooses to bear some credit risk primarily because it considers the systemic impact and cost of a liquidity shortage in the payments system much higher than the potential credit risk exposed by providing uncollateralized overdrafts.[23]

Faced with somewhat different tradeoffs between cost and risk, many European central banks have chosen to provide only fully collateralized loans as their payments systems move to RTGS systems. TBF in France, BIREL in Italy, and CHAPS in United Kingdom are a few such examples.[24] The central banks in these countries will not extend loans in payments systems unless a borrowing institution provides collateral in the form of high-quality assets, typically short-term government securities.[25]

When a central bank only provides intraday liquidity through fully collateralized loans, it does not bear any credit risk. Liquidity risk in an RTGS system, however, is reduced but not eliminated. Liquidity risk is reduced because collateralized loans are cheaper to banks than clearing balances—securities used as collateral earn positive interest while clearing balances do not. Liquidity risk is not eliminated, though, because banks will economize on the amounts of assets they hold as collateral, just as they economize on their holdings of clearing balances. While collateralized loans are cheaper than clearing balances, they are still costly in the sense that the interest earned on collateral is lower than other kinds of assets, such as corporate bonds or consumer loans. Therefore, banks tend to hold more liquidity when collateralized loans are available—now as the sum of clearing balances and collateral—but less than what is needed to eliminate liquidity risk.[26]

Credit and unwinding risk in netting systems

While credit risk also exists in netting systems, the primary component of settlement risk in these systems is unwinding risk.[27] Unwinding occurs only when a netting system fails to settle. Therefore, efforts to reduce unwinding risk concentrate on reducing the possibility of settlement failures, which often include controlling credit risk.[28] Various measures have been introduced, and three are particularly well developed: bilateral credit limits for individual participants and multilateral debit limits for the system to control credit risk exposures, collateral requirements, and loss sharing agreements to reduce unwinding risk.

Bilateral credit limits and multilateral debit limits. Bilateral credit limits control the credit risk to receivers at the individual institution level. With bilateral credit limits, each participant specifies the maximum amount of net payment it would accept from every other participant. Recall that accepting a payment is equivalent to extending credit to the sending party because payments are not settled when they are sent. Thus, bilateral credit limits essentially cap the maximal receiver risk at prespecified levels.

Each participant in the system is also subject to a multilateral debit limit. Multilateral debit limits specify the maximum aggregate net amount an institution can owe to all other participants of the system. Whereas bilateral limits control the credit risk between any two institutions, multilateral limits control the potential shortfalls of the entire system to an explicit, preestablished level when a participant fails to pay its settlement obligations.[29]

While an individual institution sets its own bilateral credit limits, its multilateral net debit limit is often based on the sum of the bilateral credit limits it receives from all other participants in the system.[30] For example, assume Dates Bank is a member of a netting system XYZ, which has 101 participants. Half of the participants set the bilateral credit limit for Dates at $20 million, while the other half set the limit at $10 million. The rule of XYZ specifies that the multilateral debit limit must equal 5 percent of the sum of a bank's bilateral credit limits. Thus, the multilateral debit limit for Dates Bank would be equal to 5 percent of $1.5 billion ($20 million times 50 plus $10 million times 50), or $75 million.

Collateral requirements. Collateral requirements, when properly combined with multilateral debit limits, can significantly reduce unwinding risk. A netting system can require each of its participants to post collateral in a system account, which will be liquidated to pay for settlement if the participant fails to fulfill its settlement obligations. To protect the system from an unwinding, the collateral requirements for a member could be set to equal its multilateral debit limit. This way, settlement is guaranteed even if members of the system fail.

While setting collateral requirements at the level of multilateral debit limits would eliminate unwinding risk, it would be costly. If the XYZ netting system in the earlier example adopts such an approach, Dates Bank would be required to provide $75 million of collateral in the system account. Thus, few netting systems have actually implemented such stringent collateral requirements.

Loss sharing agreements. Loss sharing agreements spread the cost of default in a netting system among all members. Loss sharing agreements specify the additional settlement obligations for each member when some participants cannot fulfill their settlement obligations. With loss sharing agreements, the impact of a participant's failure to pay its obligations will not be concentrated in a few institutions, thus reducing the possibility of a chain reaction. Consequently, the risks of settlement failure and unwinding are reduced as well.

By combining loss sharing agreements with multilateral debit limits and collateral requirements, a netting system can further reduce unwinding risk at little additional cost to its members. For instance, instead of requiring each member bank to provide collateral equal to its multilateral debit limits, a netting system could require a member to provide collateral equal to the maximum amount of loss that the member is required to share. As long as the total amount of collateral in the system account is greater than the largest multilateral debit limit granted by the system to its participants, settlement is guaranteed even if the member with the largest net debit position fails.[31] For instance, using the earlier example, assume Dates Bank fails with a total of $75 million in settlement obligations. As long as the total amount of all collateral posted in the system account is at least $75 million, XYZ will still be able to settle.

A potential problem with loss sharing agreements is that an individual member may extend bilateral credit limits too aggressively because it does not bear the full cost of a potential default. One way to avoid such abuses of loss sharing agreements would be to require that the shared loss for each participant vary with the bilateral credit limit it has set for the failed participants. This way, it would be in a participant's best interest to set prudent bilateral credit limits. For instance, assume Dates Bank fails with a total of $75 million in settlement obligations. Then the loss sharing agreements could require a bank granting Dates a $20 million credit limit to pay $1 million and a bank granting Dates a $10 million credit limit to pay $0.5 million.[32]

CHIPS has adopted all three of these measures, significantly reducing settlement risk, especially unwinding risk, to its members.[33] While a participant is free to set its bilateral credit limit for another CHIPS participant, both its collateral requirement and loss sharing obligations vary with this limit. Thus, it is in a participant's interest to assess a counterparty's credit risk prudently and set the bilateral credit limit accordingly. Further, with the loss sharing agreement, the required amount of collateral in CHIPS is relatively small, as are the costs of posting collateral. With these measures implemented, CHIPS is confident that it can settle even if its two participants with the largest multilateral net debit positions fail to pay their settlement obligations. As a result, CHIPS has significantly reduced its settlement risk.

IV. SUMMARY AND CONCLUSION

The extraordinary growth in large-value payments systems has increased both the risk of a settlement failure and the systemic impact of such a failure. This article discusses how settlement risk differs in RTGS systems and netting systems, and explores various measures to manage such risk. Settlement risk in these systems is composed of credit risk, unwinding risk, and liquidity risk. In RTGS systems, the main focuses of settlement risk are credit risk and liquidity risk. Credit risk can be eliminated by using DVP, although DVP is costly. Liquidity risk can be reduced if central banks provide intraday liquidity. In netting systems, the main focuses of settlement risk are credit risk and unwinding risk. Credit risk in netting systems is generally smaller than in RTGS systems, and it can be further controlled by bilateral credit limits. Unwinding risk can also be reduced significantly by properly combining collateral requirements with multilateral debit limit, and preferably, loss sharing agreements.

Which kind of payments system is likely to prevail? In Europe, the trend is moving toward RTGS systems. The main rationale behind this change is the concern of unwinding risk in netting systems. In the United States, however, CHIPS is likely to continue to be the biggest large-value payments system since it has been successful in reducing settlement risk, in particular, unwinding risk. Looking ahead, the success of CHIPS could inspire the private sectors in some European countries to set up similar systems. For these reasons, both RTGS and netting systems are likely to continue to coexist in the foreseeable future.

ENDNOTES

1 Large-value payments systems are also called wholesale payments systems, as opposed to retail payments systems, such as check clearinghouses.

2 For certain transactions, barter is an alternative. However, this is rarely the case in large-value transactions.

3 In addition to Fedwire, the Federal Reserve also operates an electronic book-entry clearing system for government securities, which is sometimes confused with Fedwire. The confusion arises partly from the linkage established between the two systems in recent years. The Federal Reserve has linked these two systems to implement a delivery-versus-payment (DVP) mechanism. With this linkage, if a payment order is generated by a government security purchasing agreement, the Federal Reserve will execute the fund and security transfers at exactly the same time on Fedwire and the book-entry system. This DVP mechanism has many advantages, which will be discussed later in the article.

4 The difference between the total credit and debit is called a "net net position" in CHIPS. A participant is said to have a negative net net position if its total debit is larger than its total credit, a positive net net position if its total credit is larger than its total debit.

5 Of course, a private bank could also serve as a settlement agent. But due to the settlement agent's pivotal role in maintaining the stability of a large-value payments system, thus its importance to the entire financial system, this private bank's bank would be under very close scrutiny of the central bank. In practice, most large-value payments systems use their central banks as the settlement agents.

6 If they do not have foreign branch offices, the transaction would have to be completed through their foreign correspondent banks.

7 See the Bank for International Settlements (March 1996) in the references.

[8] The time difference was five hours instead of the usual six hours because the United States was observing Daylight Savings Time while West Germany was not.

[9] Another form of credit risk is the credit risk to a bank that sends a payment on behalf of its customer, which is the risk that the sending bank might have paid the funds with finality only to find out that the customer does not have proper funds to pay back the bank. This risk is present whenever a bank provides overdraft service to its customers. This risk will be omitted in the discussion because it is not particular to settlement risk.

[10] This assumes that the legal base for netting is well established in the country in which the payments system is located. To understand how different legal frameworks might affect the risk exposure in a netting system, let us look at the example in Table 1. In Table 1, suppose Ash sends the instruction to pay Birch $15 million to a netting system first. Once this instruction has been accepted by the system, Ash has a legal obligation of $15 million. Now suppose Birch then sends the instruction of paying Ash $10 million to the same payments system. How much is Ash's legal obligation then? In countries where the legal base for netting is well established, its legal obligation now is the net of the two payment instructions, which is $5 million. This is called "netting by novation." In other words, Ash's credit risk is at most $5 million. In some other countries where the legal base for netting is lacking, however, Ash's legal obligation could still be $15 million.

[11] As mentioned earlier, if the legal base for netting is well established, then when one participant defaults on its settlement obligations, its counterparties no longer have the obligation to honor their payments.

[12] Because of the potential impact of an unwinding, CHIPS has implemented many risk control measures to reduce the possibility of such occurrence, some of which will be discussed later in the article.

[13] In the real world, the differences of liquidity needs between an RTGS and a netting system are typically much more striking, because the number of banks in a payments system and the cross traffic among the banks are much higher. Further, gridlock could occur even if only one of the banks does not have sufficient liquidity. It is conceivable, however, that the banks could break up their obligations and accomplish settlement by multiple payments. For example, if Ash has $2 million of liquidity, it could send out a payment instruction for $2 million to Birch, relying on Birch to pay Cedar $2 million as soon as it receives the funds, and Cedar to pay Ash. Then Ash could pay out these $2 million again and the final settlement will be achieved after enough number of cycles. This is in fact the practice in SIC (see endnote 16). Still, significant delays in settlement can be expected. Further, in a large system with many banks involved, it is inevitable that significantly more liquidity would be needed to guarantee same day settlement.

[14] Mathematically, this is equivalent to the claim that the optimal solution is an interior solution, which holds with only mild assumptions about cost structures.

[15] A halt in an RTGS system implies settlement failure, just as unwinding implies settlement failure in a netting system. In this sense, a slowdown in an RTGS system can be viewed as a partial settlement failure because it implies that many payment instructions cannot be executed in time.

[16] SIC also designs a queuing mechanism. If there are not enough funds in a sending bank's clearing balance, the payment instruction will be put into a queue to be processed on a first-in-first-out basis when sufficient funds are available. Further, a sending bank can cancel at will any payment instructions waiting in the queue. This arrangement allows a sending bank to break a large payment order into several small pieces to be processed.

[17] In 1993, on average only about half of the payment instructions were completed by 2 p.m., but 95 percent of the instructions had been initiated by that time.

[18] Another example of such measures is to increase the use of bilateral netting arrangements between institutions that have many payment orders going both ways within themselves. This will reduce both settlement risk exposures and settlement cost regardless of the type of payments system, RTGS or netting, being used.

[19] The discussion will focus on settlement rules and procedures. There are also many hardware improvements that will reduce settlement risk, such as more powerful computers, better telecommunication facilities, and better backup systems. Since the costs and benefits of the hardware improvements are easy to recognize, they will not be discussed here.

[20] Sometimes people use the term DVP loosely to describe certain link arrangements between a monetary payments system with some other clearing system, even if the former is a netting system. But true DVP, as described in the text, is only feasible for RTGS systems. Indeed, the potential for risk reduction in DVP is an important factor in the decision of European central banks to advocate RTGS systems.

[21] In terminology, this is called an externality problem.

22 In contrast, without cheap liquidity provided by the central bank, there could be excessive delays in execution caused by liquidity shortage, which introduce uncertainties as to when a particular payment instruction will be executed. If a significant portion of payment orders are delayed in a system, the system is effectively no longer *real time*, which is a crucial property required by DVP.

23 In order to manage its credit risk exposure caused by such overdrafts, the Federal Reserve has adopted two risk control measures. One is the establishment of debit limits. Since 1985, a net debit cap has been established for each member bank, which could be three times as high as a bank's regulatory capital. The debit cap is "soft" in the sense that a bank is allowed to exceed its debit cap. But banks are strongly discouraged from doing so. If a bank is found exceeding its debit cap repeatedly, it will receive increasing administrative and regulatory scrutiny from the Federal Reserve. Fedwire also has the option of rejecting a payment instruction if accepting it would cause the sending bank to exceed its debit cap. If a bank is unable to maintain a positive balance in its account with the Federal Reserve at the end of the day by its own fund or privately borrowed fund, the overdraft would be viewed as a discount window borrowing and proper collateral is required. The other risk control measure is charging fees on daylight overdrafts. Since April 1994, the Federal Reserve has imposed a fee on daylight overdrafts to give banks a market incentive to reduce their usage of overdrafts.

24 The German central bank is planning to provide partially collateralized overdrafts for its proposed RTGS system.

25 In this case, the provision of liquidity can take the form of either fully collateralized loans or intraday repurchase agreements.

26 There is also a credibility issue. Since a central bank's policy of providing only fully collateralized loans will not eliminate the possibility of liquidity shortage, private sectors may expect central banks to step in with needed liquidity, i.e., uncollateralized loans, when large-scaled liquidity shortage occurs. In other words, the policy might not be credible. After all, once a genuine liquidity shortage occurs, it improves everyone's welfare for central banks to resolve the shortage. Therefore, central banks unwilling to assume any credit risk might be, in fact, assuming much liquidity risk. A perfect policy does not exist; there are only choices with different tradeoffs.

27 As mentioned earlier, the legal framework for netting is important as well, which is beyond the scope of this article.

28 There is also some effort to shorten the time length of settlement cycles by increasing settlement frequencies. Some countries, such as Germany, have planned to move in this direction. The idea is that with a shortened cycle, the total amounts of accumulated payments will be smaller and so will the unwinding risk. Basically, this approach moves a netting system toward the direction of an RTGS system. Thus, such a change will reduce unwinding risk at the expense of increasing liquidity risk. This tradeoff is similar to the tradeoff between RTGS and netting systems.

29 The bilateral and multilateral credit limits in a netting system are equivalent to the clearing balance in an RTGS system. If the limits for an institution are set at zero, for example, then the institution will not be able to send any payments through the system. Thus, there is a tradeoff between lowering the limits and smooth operation of the system.

30 These should be "hard" caps in the sense that they cannot be exceeded. For example, in CHIPS, when a payment instruction arrives, the central processing computer updates the bilateral and multilateral net debit positions of the sender (payer) and compares them with the preestablished limits. If a bank's payment will cause it to exceed either of the caps, the payment instruction will not be accepted or released to the receiver and the sender could choose to delete it from the system.

31 A netting system that is able to settle even if one of its participants with the largest net debit position fails to settle is said to satisfy the first of a set of standards known as the Lamfalussy criteria, "Lamfalussy one." Lamfalussy one is now commonly accepted as one of the basic criteria that a well-structured netting system should meet. Clearly, a netting system that satisfies this criterion has much lower unwinding risk.

32 The numbers in the example are obtained by assuming that the loss sharing agreements specify that each member's share of loss is equal to the ratio of its the bilateral credit limit to Dates Bank to the sum of all bilateral credit limits Dates receives. Thus, a bank granting Dates a \$20 million bilateral credit limit has a share of 1/75 (\$20 million over \$1,500 million) of Dates Bank's payment obligations of \$75 million, which is \$1 million. Similarly, a bank granting Dates a \$10 million bilateral credit limit shares a loss of \$0.5 million.

33 In fact, many of these risk management measures were originated in CHIPS.

REFERENCES

Angelini, P., G. Maresca, and D. Russo. 1995. “Systemic Risk in the Netting System,” *Journal of Banking & Finance*, vol. 20, pp. 853-68.

Bank for International Settlements. 1996. *Settlement Risks in Foreign Exchange Transactions*, Committee on Payment and Settlement Systems of the Central Banks of the Group of Ten Countries, March.

_____________. 1992a. *Recent Developments in International Interbank Relations*, Working Group established by the Central Banks of the Group of Ten Countries, October.

_____________. 1992b. *Delivery Versus Payment in Securities Settlement Systems*, Committee on Payment and Settlement Systems of the Central Banks of the Group of Ten Countries, September.

_____________. 1990. *Report of the Committee on Interbank Netting Schemes of the Central Banks of the Group of Ten Countries*, November.

Berger, Allen N., Diana Hancock, and Jeffrey C. Marquardt. 1996. “A Framework for Analyzing Efficiency, Risks, Costs, and Innovations in the Payments System,” *Journal of Money, Credit, and Banking*, November, Part 2.

Clair, Robert T. 1989. “The Clearing House Interbank Payments System: A Description of Its Operation and Risk Management,” Federal Reserve Bank of Dallas, Research Paper No. 8910, June.

Clearing House Interbank Payments System. 1996. *CHIPS Rules and Administrative Procedures.* New York: New York Clearing House Association.

_____________. 1995. *Risk Reduction and Enhanced Efficiency in Large-Value Payment Systems: A Private-Sector Response.* New York: New York Clearing House Association, January.

Cronin, David. 1995. “Wholesale Payment Systems—Current Issues and Developments,” Central Bank of Ireland, Technical Paper No. 7\RT\95, December.

Dale, Spencer, and Marco Rossi. 1996. “A Market for Intra-day Funds: Does It Have Implications for Monetary Policy?” Bank of England.

Engert, Walter. 1992. “An Introduction to Multilateral Foreign Exchange Netting,” Bank of Canada, Working Paper 92-5, September.

Folkerts-Landau, David, Peter Garber, and Dirk Schoenmaker. 1996. “The Reform of Wholesale Payment Systems and Its Impact on Financial Markets,” Group of Thirty, Washington, DC, Paper 51.

Furfine, Craig, and Jeff J. Stehm. 1996. “Analyzing Alternative Daylight Credit Policies in Real-Time Gross Settlement Systems,” presented at the Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, May 1-3.

George, E. A. J. 1996. “Look at What Needs to Be Done to Further Reduce Risks in Payment and Settlement Systems,” presented at the Gilbart Lecture organized by the Chartered Institute of Bankers at King’s College, London, October 22.

Goldman, Sachs & Co. 1996. “Risk Reduction in Payments, Clearance, and Settlement Systems,” a symposium at the Pierre Hotel, New York, January 25-26.

Humphrey, David B. 1989. “Market Responses to Pricing Fedwire Daylight Overdrafts,” *Economic Review*, Federal Reserve Bank of Richmond, May/June, pp. 23-34.

McAndrews, James J., and George Wasilyew. 1995. “Simulations of Failure in a Payment System,” Federal Reserve Bank of Philadelphia, Working Paper No. 95-19, June.

Mengle, David L. 1990. “Legal and Regulatory Reform in Electronic Payments: An Evaluation of Payment Finality Rules,” presented at a symposium on the U.S. Payment System, Federal Reserve Bank of Richmond.

Moser, James T., William J. Hanley, and Karen McCann. 1996. “Public Benefits and Public Concerns: An Economic Analysis of Regulatory Standards for Clearing Facilities,” presented at the Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, May 1-3.

Patrikis, Ernest T. 1996. “Some Visions of Large Value Payment Systems,” presented at the 14th Payments System International Conference, Montreaux, October 23.

Padoa-Schioppa, Dott. Tommaso. 1996. “Major Features of and Developments in the International Payments System,” presented at the SIBOS 1996 Conference held by the Society for Worldwide Interbank Financial Telecommunication, Florence, Italy, October 10.

Richards, Heidi Willmann. 1995. “Daylight Overdraft Fees and the Federal Reserve’s Payment System Risk Policy,” *Federal Reserve Bulletin*, December.

Schoenmaker, Dirk. 1995. “A Comparison of Alternative Interbank Settlement Systems,” London School of Economics, Financial Markets Group, An ESRC Research Centre, Discussion Paper No. 204, March.

_____________. 1993. “Externalities in Payment Systems: Issues for Europe,” London School of Economics, Financial Markets Group, Special Paper Series, Special Paper No. 55, September.

Sheppard, David. 1996. “Payment Systems,” *Handbook in Central Banking No. 8*, Centre for Central Banking Studies Bank of England, May.

VanHoose, David, and Gordon H. Sellon, Jr. 1989. “Daylight Overdrafts, Payments System Risk, and Public Policy," *Economic Review*, Federal Reserve Bank of Kansas City, September/October, pp. 9-29.

Vital, Christian. 1996. "The Architecture of Real-Time Gross Settlement Systems," presentation at the Hong Kong Monetary Authority Seminar on Global Payment Systems, Hong Kong, November 2-3.